ALTERNATIVE ENERGY WORKSHOP

STARS and Daylighting in Campbell Hall

Global Sustainability, Spring 2013
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ABSTRACT

As a team, we set out to accomplish two goals: update the The Sustainability Tracking, Assessment & Rating System™ (STARS) report for Campbell Hall and perform a lighting audit in the studio areas of Campbell Hall with the hopes of implementing a daylighting system. STARS is a uniform method for determining and reporting the sustainability of universities and institutions of higher learning. Global Sustainability Workshop groups from the past few years have compiled full STARS reports to evaluate Campbell Hall's sustainability performance. However, in the summer of 2012, Delta Force implemented new lighting changes that will positively affect the University's score, and therefore we sought to update the report to reflect these important updates in lighting. As aforementioned, in addition to working on an updated STARS report, we wanted to assess what changes could be made to directly impact the sustainability of Campbell Hall through a lighting audit. A daylighting system seemed a valuable yet feasible option to pursue, and if implemented, could have drastic positive effects on the energy usage in Campbell Hall. A daylighting system would monitor ambient light levels in the studio areas on the third and fourth floors, and turn lights off or on in order to achieve an ideal level of usable light. Currently, all light zones are always on, but we hypothesized that during times of high levels of natural light, the studio space receives enough natural light through the windows and skylights to make the current LED lights superfluous. The bulk of our project focused on collection of thorough measurements of light levels throughout the studio areas at various times throughout the day, with and without lights, and with varying weather conditions. These measurements provide provide baseline light levels that will be compiled into a feasibility report and presented to Delta Force, with the goal of installing an effective daylighting system in Campbell Hall.

INTRODUCTION

The ultimate goal of our project is to reduce energy use in Campbell Hall. As the central building of the University's School of Architecture, the infrastructure of Campbell Hall has already been renovated and modified to promote sustainability and reflect the school's focus on green architecture. Delta Force, a cross-functional team-based group from the University's Facilities Management sector focused on retro-fitting existing buildings with a concentration on energy and water conservation, is currently in the process of replacing most of the compact fluorescent lights in Campbell with LED bulbs, and motion sensors have also been installed in all bathrooms to turn off lights when not in use. These modifications show a dedication to sustainability; however, according to the STARS report published last year and the opinions of some faculty, there is room for improvement in other areas of the building.

The STARS analysis from the previous year lists the following six energy management practices that Campbell Hall could possibly engage in: utilize power save mode on all electronic devices, use energy efficient light bulbs throughout the building, use motions sensors for lighting and vending machines throughout the building, implement solar water heating system, install proper and effective insulation to reduce reliance on heating and cooling, and alternative energy sources. While some of these plans have already been put into place since the report was published, such as the change in light bulbs and installation of motion sensors mentioned earlier, others have not for various reasons, such as the difficulty of implementation and economic costs . For example, plans for installation of new insulation and solar panels involve extreme costs and could potentially take years to implement, if even implemented at all.

Therefore, our team has focused on providing a practical update to the STARS report from previous years that clearly demonstrates the advancements in lighting in Campbell Hall. Additionally, we have researched and collected data on the third and fourth floor studio areas of Campbell Hall in order to determine whether or not the incorporation of a daylighting system would prove to be feasible. The findings from our research and data, presented later in this report, will be presented to the Delta Force, who will fund the implementation of appropriate sensors and appliances necessary for daylighting if our data and research reasonably supports this conclusion.

STARS REPORT

The first major component of our project is the update to the STARS report for the energy expenditures of the School of Architecture's Campbell Hall. STARS stands for the Sustainability Tracking Assessment and Rating System and is a standardized point and grading system for colleges and universities across the United States to understand the sustainability performance of their buildings. The main objective for this reporting system is to increase the institution's awareness of their effect on the environment and provide a framework for a performance comparison across multiple years. This is incredibly important for sustainability because it has the ability to offer incentives for institutions to reduce their impact and it creates a diverse and wide reaching community for colleges and universities focused on sustainability. Andrew Greene, the Sustainability Planner for all of UVA, was an incredible asset to the project. He helped us understand the scoring system of STARS, provided information on the building's energy usage and square footage, and acted as our sole liaison for this section of our project.

We focused on updating the extensive STARS report that was created last year for two reasons. Firstly, since the last report was carried out, a version 1.2 of STARS has been released that includes improvements to scoring and reporting methods. We wanted the University's score to be as current and relevant as possible, and to include these more recent changes. Secondly, we wanted our report to reflect the changes in the lighting systems of Campbell Hall, part of the Architecture School, which occurred as a result of the suggestions from the last STARS report compiled by a Global Sustainability Workshop group. With the support of the Architecture School, Delta Force was able to replace the compact fluorescent light bulbs used in Campbell Hall with more energy-efficient LED light bulbs. Because this major change in lighting was expected to significantly reduce the consumption of electricity in Campbell Hall, we amended the report to show this score improvement. The portion of the report dealing with the lights is a subcategory of the Energy section, separate from the Water and Climate sections. This particular section was the only part that needed to be modified, due to the fact that no major changes have occurred since the previous year's analysis to affect the score.

Previous STARS Report

The lighting system was included in the Energy BMP (best management practice) section of the group's report. Each BMP investigated last year was assigned a score based on its importance in the STARS rating, cost to the school, feasibility, and amount of infrastructure change. Below is an excerpt from the group's paper that includes their table with explanation of the lighting change BMP score:

Energy BMPs

Use energy efficient light bulbs throughout the entire building

Energy efficient light bulbs require less power than incandescent light bulbs. Depending on the amount of money that the school would like to allocate towards efficient lighting, there are several viable options. The most efficient light bulbs are the LED (light emitting diode). These light bulbs shine brighter and last longer than most CFL (compact fluorescent lamp) bulbs. They are also the most expensive option. Other options include the CLF bulbs and Halogen light bulbs.

Index of Performance	Score	Reasoning
STARS Rating	1	LED Lighting accounts for 0.25 points in the STARS rating.
Cost	2	It would cost the school roughly $2556 to purchase 64 LED light bulbs. Depending on the number of light bulbs needed on each floor, purchasing light bulbs alone could cost the school between $3000 and $10,000. It would then cost the school between $20,000 and $50,000 to rewire the entire building and install all of the LED light bulbs.
Feasibility	4	This would require a small team to install the new lighting features.
Infrastructure	4	Installing LED bulbs would require the rewiring of the building, which could result in minor infrastructural changes.
Total Score	11	

Excerpt from STARS Report, 2012

Updated STARS Report

Below are our updates to the past year's report, specifically in the energy section. These updates consider the replacement of compact fluorescent bulbs with LED bulbs, and any other energy saving implementations made since the previous year.

STARS Ratings

Energy

Credit Number	Credit Title	Points Available	Current Score	Potential Score
OP Credit 7	Building Energy Consumption	8	2.621	4.121

Power save modes on all electronics will reduce the energy consumption by around 10% and thus increase the STARS rating score by an estimated 1.34 points.

OP Credit 8	Renewable Energy	7	0	0

This credit was not assessed in last year's STARS report because it involved the entire University's energy instead of focusing on just Campbell Hall. The group could not accurately assess these point values. Nothing in this field has changed since the building was assessed in the previous report.

Tier Two	Energy Tier Two Credits	1.5	1	1

The points for this category of the report were the same as the previous report because though LED lights were installed in Campbell Hall which awarded the building an additional 0.25 points, the lighting sensors in the classrooms that were also worth 0.25 points in the rating system were removed so the overall score remained at 1. The benefits of the installation of the LED lighting system are reflected in the increase in the score for the OP Credit 7, which reflects the total building energy consumption.

DAYLIGHTING IN CAMPBELL HALL

Daylighting is the practice of using natural light from windows and skylights in a building to reduce the need for artificial lighting. This is an easy way to reduce energy use at little or no cost. However, not all areas of a building can benefit from switching to complete natural light. A few factors must be taken into account to determine if natural light will be sufficient for a room. First, the climate in which a building is located must be accounted for. A building in a particularly cloudy region, such as the Pacific Northwest, might not receive enough natural light on the average day to make much of a difference. In addition to climate, the direction a room's windows face in relation to the sun is also an important factor. Windows facing west, for example, will only receive direct sunlight at the end of the day. There are also important national and state regulations on light levels for offices and other workspaces that must be adhered to. The guidelines for lighting we chose to follow are those regulated by the IESNA (Illuminating Engineering Society of North America), which can be found in the Appendix. Finally, a room's purpose dictates exactly how much light it needs. For example, Work areas such as offices and kitchens typically require more light than hallways and stairwells.

Precedent Analysis

When considering daylighting technology in relation to energy consumption in Campbell Hall, we conducted research, and specifically focused on the following precedents as models of sustainable buildings on grounds and in the Charlottesville area. Rice Hall was opened for use in the fall of 2011, the new home of the Department of Computer Science and the Computer Engineering Program. This building is six stories that cover over 100,000 square feet, was designed for Leadership in Energy & Environmental Design certification, commonly known as LEED, and is at the forefront of air and power technology. These technologies include "chilled beams" that use water instead of air to remove heat from rooms – a new technology for University facilities. All of the sophisticated technologies for heating, cooling and lighting are collecting data as student and faculty go about their daily routines. In that way the building will help researchers learn how to optimize the latest energy technologies for large buildings and energy consumption. Additionally, the research could inform behaviors for reduction in energy consumption on a smaller scale, such as closing doors, turning off lights or powering down equipment. We chose to focus on how Rice Hall utilizes the data collected throughout the building on a day-to-day basis; using Rice Hall's living laboratory model, we used our own data collection and analysis in dissemination and student awareness efforts.

http://uvamagazine.org

http://alpolic-usa.com

Rice Hall, Univeristy of Virginia

ecoMOD and ecoREMOD are projects are conducted in the Charlottesville area under the instruction of UVa faculty in both the School of Architecture and the School of Engineering and Applied Sciences. ecoREMOD specifically focuses on retrofitting and adapting historic buildings to more sustainable standards, while ecoMOD focuses on the creation of environmentally sound and highly efficient housing units for affordable housing organizations. Although directed by faculty members of the University, students manage and participate in almost all aspects of ecoMOD and ecoREMOD programs. These student teams come from a variety of different backgrounds and disciplines, and the various facets of these projects involve design, construction and evaluation of both new housing units and retrofitted houses in the Charlottesville area. ecoMOD and ecoREMOD provide valuable lessons not only on how to effectively and affordably implement sustainable solutions, but also serve as an important model on student group work that is loosely guided and supervised by faculty members. Additionally, they collect a plethora of data during the multiple stages of the design process, and there are important lessons to be learned from their usage of this data in improving design efficacy.

http://ecomod.virginia.edu

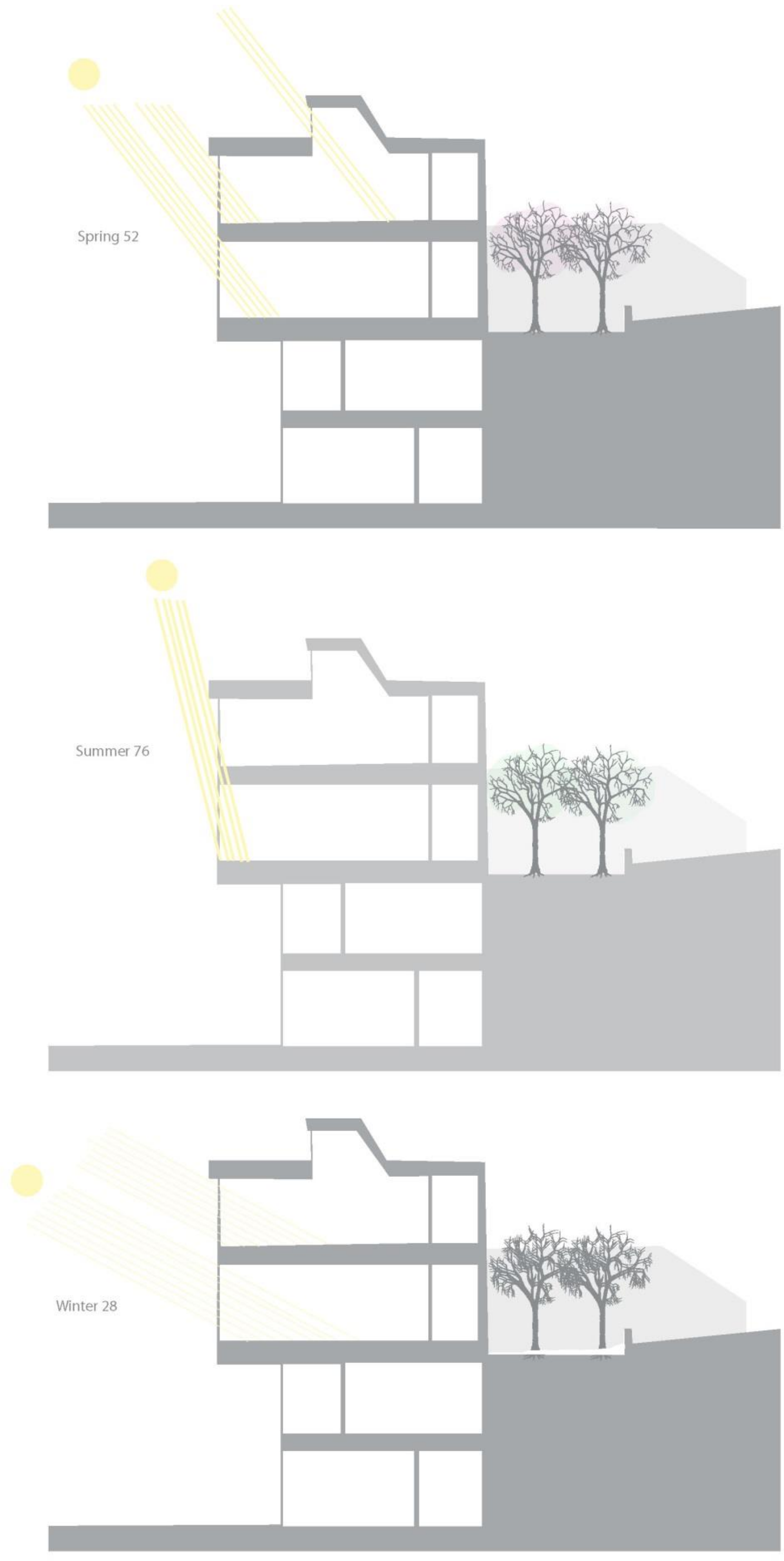
EcoMOD, Charlottesville, VA

http://www.charlottesville.org

EcoREMOD, Charlottesville, VA

Campbell Hall Daylighting Feasibility

Campbell Hall's studio areas would benefit greatly from a daylighting system as the building already has the infrastructure and design that highlights the northern light and large windows needed for the daylighting system. This would put the lights on a solar sensor that would automatically adjust according to the amount of sunlight there is. For example, the lights closest to the window on a sunny day would turn off if the light levels were high enough. The schematic diagrams below show the sunlight in winter, spring and summer and how the studio spaces closest to the windows get direct sunlight, dependent on the sun's path, strength and declination.



Transverse Sections N-S of Campbell Hall, showing sunlight during spring, summer and winter

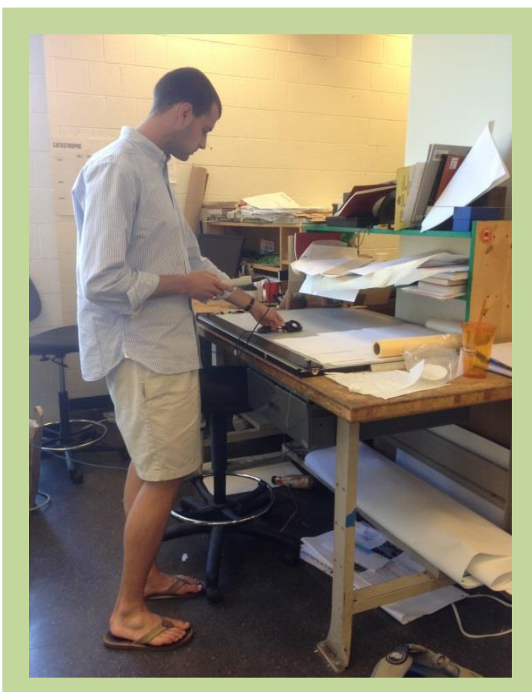
To explore the possibility of daylighting the third and fourth floor architecture studios in Campbell Hall, extensive data was collected. This project demanded a somewhat complicated and thorough data collection process for both floors. The 3rd and 4th studio areas of the Architecture School were divided into sections and labeled with numbers based on what number light switch controlled the lighting in that area. Two data points were determined for each numbered area, one closer to the windows or lights and the other in a more shaded areas.

These plans show the layout of the third (bottom) and fourth (top) floors. The colors illustrate the lighting zones as they correlate to the electrical box and the numbers are the data locations. We focused our attention on the areas highlighted in red, as they are closest to the northern windows.

Daylighting Data Collection in Campbell Hall

Data was collected for the shelf and desk area for points that were in workspace areas. Using a light monitoring device called a light meter provided by Facilities Management of the Architecture School, the level of light was recorded in foot candles. The first round of collection was taken with all of the lights on, and then, all the lights were turned off and the data was recorded for the same locations. This testing was done at approximately 12:00pm, 2:00pm, and 4:00pm on a sunny, overcast or cloudy day. Our team also conducted one round of data collection at night, with the lights on, to serve a baseline for the level of light provided by the LED lights currently in use in the studio areas.

The picture above shows the light meter used during data collection to monitor the ambient light levels in the studio areas of Campbell Hall. All light levels were recorded in foot candles, and some important features include the range button, which allows for more accurate measurements, and the zero button which allows for the instrument to record consistent data.



The three images above show daytime data collection of the light levels using the light meter (Photos by Morgan Stackman)

Daylighting Data and Results

As expected, light levels with the lights on were considerably higher than those with the lights off. Using the "lights only" values recorded at night as control values, we also see that natural light does positively affect light levels during the day. The fourth floor received more light in all weather conditions but we see more light measured on cloudy days than on sunny days under almost all scenarios. This may be due to greater reflection of light into the building induced by cloud cover. All "lights off" values were below the target value of 30 foot candles. Since median values were calculated using data from all lighting zones, this does not exclude all zones from consideration for a daylighting system; only a handful of specific zones. All the raw data collected, both on the third and fourth floor, at different times of day and under varying weather conditions, can be found tabulated in the Appendix.

3rd floor	Lights On	Lights Off	**4th floor**	Lights On	Lights Off
Sunny	42.6	20.1	Sunny	55.2	21.7
Cloudy	41.7	26.6	Cloudy	67.7	28.7
Night	30.8		Night	37.0	

Table 1 illustrates ambient light levels measured in foot candles in Campbell Hall with the lights on vs. lights off under varying weather conditions. Median values are displayed in order to nullify the effects of outliers.

The three images above picture a few regions within the northern region of the studio areas in which daylighting may be feasibly implemented.

Delta Force is currently looking at the data collected from Campbell Hall and considering a daylighting project in the 3rd and 4th floor studios. The project will need to be economically feasible, meaning the building could save enough money over the next two years to cover Delta Force's initial investment. This will involve calculating the average amount of time artificial lights could be turned off every day, and multiplying that by the cost of electricity. There is also the option of installing sensors in the remaining third and fourth floor spaces, as well as motion detectors to detect when spaces are not being used. A combination of motion detectors and a light dimming system could increase energy savings by up to 30%. If economically feasible, the project itself will involve installing light sensors in the zones closest to the north windows to detect when there is enough natural light to work without artificial light. On sunny days, some of these zones will most likely not require any artificial light at all. The light sensor of interest is the Radio Pwr Svr from Luton Electronics. Benefits include no additional necessary wiring, 10 year battery life, and can be mounted on either side walls or ceilings.

The light sensor would be used to implement daylighting through monitoring of light levels. The sensor turns the lights on or off depending on programmed values of acceptable light levels. The Radio Pwr Svr from Luton Electronics was recommended by Delta Force, who would oversee the installation of this device.

CONCLUSION

In Conclusion, our data demonstrates that it would benefit both the students and the school to implement a lighting sensor. There are large windows on the north side that would provide sufficient light for students to work. After taking data on all of the third and fourth floors, it seemed like it would work best in these zones closest to the windows. We found that the shelves students put on their desks can make their work area dark and we would suggest for the students to decide carefully about their furniture. When taking the data, the surroundings students seemed very interested in following through on this. As a team we learned a lot about the steps involved to implement a daylighting system like this. Delta Force will take all of our data in consideration of implementing this over the next few years.

Lessons Learned

Our team was very successful in organizing and planning the project right from the start. We were able to set clear goals during the first couple meetings, and everyone got to work fairly quickly. The team was effective in contacting the right people and securing the necessary diagrams, as well as the light meters. We charted the lighting zones neatly, and established a procedure to collect data.

Collecting the data proved to be a more intensive process than we had originally thought. Taking measurements twice on both floors with the lights on and off, plus measuring at different heights at every location, took a very long time. Even with two people working, the process took about two hours, enough time for the sun to shift and slightly change the lighting conditions. With other classes and projects to work on, the team struggled to make the time commitment necessary to take a lot of data. Ideally, we wanted a few more days of data under different conditions but ultimately we were unable to fit that into the project's timeframe.

The data we were able to collect is still very useful to our report and to Delta Force. Future projects like this, however, would definitely benefit from more manpower. Focusing data collection on more specific areas rather than the entire studio space might also help yield better results and require less time.

APPENDIX

Budget

This project does not have a budget, as the project solely consists of data collection through a lighting audit of the third and fourth Floors of Campbell Hall and an update of the STARs analysis. However, both the lighting audit, and the updated STARS report will be taken under serious consideration by the administration of Campbell Hall and Delta Force with regards to potential implementations of feasible low-cost but effective changes. Specifically, the group plans to present its data on daylighting and related research on daylighting and sensors to Delta Force, who will fund the installation of appropriate appliances if the data supports the implementation of daylighting.

Dissemination

Once we have our results from the lighting audit and an updated STARs report, we will give our findings to the administration of the School of Architecture, and Delta Force. The bulk of our distribution will be of the results of our STARS report that we deem most pertinent to students and faculty. Additionally, our poster was entered in the 5^{th} Annual Sustainability Project Poster Challenge at the University of Virginia, which allowed us to share our findings with a larger group outside of the administration of the Architecture School and Delta Force.

However, the most pertinent dissemination of work will be our final presentation, which includes a final poster and report, which will not only be presented to our fellow students in Global Sustainability, but also serve as a basis for the incorporation of daylighting in Campbell Hall's third and fourth floor studio spaces. Specifically, the final version of our report and poster will be presented to Delta Force, who have agreed to actively pursue and fund the implementation of daylighting if the data we collect appropriately supports the assertion that daylighting would make a significant positive environmental impact in Campbell Hall with regards to energy.

Important Contact Information

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Special thanks to the following people who were instrumental in the completion and throughout the duration of our project:

Jesse Warren
Andrew Greene
Dick Smith
Dean Tanzer

Schedule

STARS and Daylighting in Campbell Campbell Hall Project Timeline				
Task Description	**Due Date**	**Participants**	**Completed?**	**Notes**
Project Description	2/20/2013	all	yes	
Project Analysis and Project Plan	2/20/2013	all	yes	
Contact Delta Force	2/20/2013	Emily	yes	
Contact Dean Tanzer	2/20/2013	Morgan	yes	
Group meeting with Delta Force	3/1/2013	all	yes	discuss daylighting and audit
Meeting with Dean Tanzer	3/1/2013	Morgan	yes	discuss daylighting and paper towels
Contact Andrew Greene	3/4/2013	Brett	yes	Provided data on Campbell Hall energy use from 2004 to 2012
Establish final plans for audit (if necessary)	3/22/2013	all	yes	
Diagrams and Tables for Daylighting Created	3/25/2013	Morgan	yes	
STARs Report Update	4/2/2013	Brett and Emily	yes	
First Draft of Final Report	4/3/2013	all	yes	Compiled by Brittany
Daylighting Data Collection	4/3/2013-4/8/2013	all	yes	3rd and 4th Floor Studio
Final Poster	4/24/2013	all	yes	Competed in Competition
Final Report	5/4/2013	all	yes	

LIGHTING DESIGN – FOOTCANDLE RECOMMENDATIONS

Currently Recommended Illuminance Categories & Illuminance Values For Lighting Design—Target Maintined Levels

The tabulation that follows is a consolidated listing of current illuminance recommendations. This listing is intended to guide the lighting designer in selecting an appropriate illuminance for design and evaluation of lighting systems.

Guidance is provided in two forms: (1), in Parts I, II, and III as an Illuminance Category, representing a range of illuminances and (2), in parts IV, V and VI as an Illuminance Value. Illuminance Categories are represented by letter designations A through I. Illuminance Values are given in lux with an approximate equivalence in footcandles and as such are intended as target (nominal) values with deviations expected. These target values also represent maintained values.

This table has been divided into the six parts for ease of use. Part I provides a listing of both Illuminance Categories and Illuminance Values for generic types of interior activities and normally is to be used when Illuminance Categories for a specific Area/Activity cannot be found in Parts II and III. Parts IV, V and VI provide target maintained Illuminance Values for outdoor facilities, sports and recreational areas, and transportation vehicles where special considerations apply.

In all cases, the recommendations in this table are based on the assumption that the lighting will be properly designed to take into account the visual characteristics of the task.

I. Illuminance Categories and Illuminance Values for Generic Types of Activities in Interiors

TYPE OF ACTIVITY	CATEGORY	RANGES OF ILLUMINANCES		REFERENCE WORK-PLANE
		LUX	FOOTCANDLES	
Public spaces with dark surroundings	A	20-30-50	2-3-5	General lighting throughout spaces
Simple orientation for short temporary visits	B	50-75-100	5-7,5-10	
Working spaces where visual tasks are only occasionally performed	C	100-150-200	10-15-20	
Performance of visual tasks of high contrast or large size	D	200-300-500	20-30-50	
Performance of visual tasks of medium contrast or small size	E	500-750-1000	50-75-100	Illuminance on task
Performance of visual tasks of low contrast or very small size	F	1000-1500-2000	100-150-200	
Performance of visual tasks of low contrast and very small size over a prolonged period	G	2000-3000-5000	200-300-500	Illuminance on task, obtained by a combination of general and local (supplementary lighting)
Performance of very prolonged and exacting visual tasks	H	5000-7500-10000	500-750-1000	
Performance of very special visual tasks of extremely low contrast and small size	I	10000-15000-20000	1000-1500-2000	

Daylighting Data

THIRD FLOOR, LIGHTS ON

		4/3, 8:10pm Night Control	4/6 10AM Sunny	4/6 12PM Cloudy	4/6 4PM Sunny	4/7 10AM Cloudy	4/7 2PM Sunny	4/7 4PM Sunny	4/9 10AM Sunny
OBJECTID	Location								
1	11a	3	200.7	244	729	34.6	29.2	294.2	336
2	11b	12.96	99.6	35.7	30.6	115.2	107.4	35.8	37.2
3	11c	18.16	76.7	65	56.8	50.6	66.9	51.3	95.3
4	11d	65.8	33.5	42.6	63.7	28	25.4	97.8	142.3
5	2a	29.25	86	35.5	41.4	141.4	97.3	34.9	43.5
6	2b	9.65	23.8	39.4	21.2	28.4	28.3	18.9	29
7	2c	50.6	69.5	72.2	56.7	89.4	87.4	63.1	56.2
8	2d	32.06	49.8	69.8	48.5	70.1	62.3	49.1	55.6
9	6a	31	20	74.8	71.3	106.4	77.2	38.2	47.5
10	6b	39.4	208.6	35.3	38.7	26.6	26.4	39.7	41.2
11	6c	45	48.6	53.3	45.5	59.6	62.7	45.5	50.2
12	6d	31.8	30.3	35.1	35.7	40.8	42.9	36.4	36.9
13	9a	29.13	32.7	28.6	37.8	32	33	43.2	48.6
14	9b	46.1	55.5	57.8	86.1	46	57.4	54.9	69.3
15	9c	45	44.7	75.8	54.1	64	56.3	63.4	63.9
16	3a	32.6	41.3	39.6	81	×	68.1	50.9	47.7
17	3b	46.4	53.7	53.1	45.3	68.6	68.1	51.3	53.5
18	1a	45.4	50.4	53.3	69.4	39.5	40.2	64.8	45
19	1b	43.7	52	50.5	48	45.6	53	46	48.6
20	5a	25.8	29.8	36.2	69.3	33	28.8	46.6	28.2
21	5b	28.1	30.2	40.2	36.5	40.2	41	39.4	39.3
22	4a	23.8	30.6	34.5	28.6	27.1	33.2	34.8	45.9
23	4b	18.6	23	22.7	19.2	41.7	45.7	19.9	22.7
24	4c	18.6	11.4	×	25.3	18	15.1	27.5	25.6
25	12a	74	52.8	27.3	48.6	54.3	51.9	47.7	76.6
26	12b	68.7	36.9	52.8	28.6	42.8	37.9	29.5	67.7
27	12c	15.9	16.1	24.1	18.5	17.6	19.9	12.9	19.4
28	20a	64.4	31.4	43.1	53.1	58.6	62.5	59.6	78.6
29	20b	51.8	44.8	28.8	31.7	52.8	53.6	32	63.1
30	20c	23.2	30.2	36.1	30.1	36	34.8	26.4	40.7
31	16a	59.6	48.1	41.5	39.3	70	52.4	48.9	88.3
32	16b	55.9	30.5	30.6	30.5	33.1	33.7	31.8	50
33	16c	19.7	17.4	23.4	22.2	21.3	×	21.8	24.5

34	12d	18.2	40.8	39.9	32.5	49.9	62.4	45	60.6
35	12e	36.1	39.4	36.1	33.8	31.5	35.3	40.8	46
36	12f	24.5	23.8	28.3	30.3	23	8.61	27.3	35.1
37	8a	9	123.1	42.8	47	270.9	304	53.7	50.5
38	8b	31.3	81.8	120.5	114.4	203.6	201.6	106.1	151
39	8e	×	×	×	27	×	×	22	×
40	8d	27.6	28.6	33.6	34.6	42.2	43.3	39.8	51.8
41	2e	30.8	39.4	37.6	65	96.1	92.5	61.2	85.4
42	2f	38	41.8	28.6	40.3	30.5	24.7	43.5	42.5
43	2g	23.1	28.9	28.7	29	28.4	28.9	23.9	31.5
44	3c	38.3	40.2	41.3	46.8	30.4	49.7	50.1	41.9
45	3d	40.9	45.1	45.1	45.1	36.4	56.8	46.6	43.3
46	11f	22.7	29.1	67.3	90.8	30.1	34.1	118.7	35.2
47	11g	24.3	22.7	165	93.2	88.2	92.8	211.4	87.1
48	9d	14.3	43.3	39.4	28.6	31.9	23.9	25.1	39.6
49	9e	×	×	×	60.6	×	×	66.6	35.9
50	9f	23	37.7	46.3	37.6	43.2	36.8	42.6	72
51	9g	27.4	35.5	35.4	35.5	41.6	42.6	25.7	41.2

THIRD FLOOR, LIGHTS OFF

		4/6 10AM Sunny	4/6 12PM Sunny	4/6 4PM Sunny	4/7 10AM Cloudy	4/7 2PM Sunny	4/7 4PM Sunny	4/9 10AM Sunny
OBJECTID	Location							
1	11a	174.8	265.7	745	520	532	269	321.2
2	11b	86.1	40.5	35.6	17.8	21	39.6	11.4
3	11c	60.9	27.9	31.5	75.6	72.9	11.8	99.2
4	11d	11.23	13	18.9	24.1	23.5	95.7	159.8
5	2a	57.1	41.8	×	212.5	207.4	23.4	24.1
6	2b	29.26	30.7	×	424	379	10.9	17.9
7	2c	127.8	53	×	114.1	110.2	32.8	38.4
8	2d	37.7	20.2	×	58.4	62.7	17.4	24.6
9	6a	36.3	36.1	51.3	17.1	18.5	29	30.7
10	6b	171.3	28.2	22.2	18.5	20.1	22.2	22.6
11	6c	17.21	17.7	15.8	12.8	17.9	13.4	17.1
12	6d	8.9	10.8	11.9	18.4	9.76	8.8	10.9
13	9a	6.93	6	19.6	8.7	6.23	17.8	31.8
14	9b	9.54	14.3	16.5	11.2	10.8	10.2	21.5
15	9c	27.1	40.2	44.8	24.6	33.6	40.8	67.2
16	3a	×	5	12	×	×	6.4	2.5
17	3b	15.1	12.2	9.8	16.2	17.4	9.8	15.3

18	1a	20.77	10	28.2	5.9	13.72	18.1	4.1
19	1b	12.31	14.4	11.3	12.4	12.52	10.3	12.1
20	5a	9.89	9.2	57.5	8.5	7.67	30.1	6.7
21	5b	5.63	10.6	13.1	4.8	10.3	11.9	12.8
22	4a	10.75	15.8	20.1	17.3	11.34	14.3	27.3
23	4b	11.05	9.9	9.9	13.1	13.4	10.6	9.5
24	4c	14.05	13.8	17.4	12.9	13.8	17.4	15.7
25	12a	27.63	26.4	23.8	24.4	29.2	23.7	48.1
26	12b	25.75	28.3	26.4	50.9	24.73	28	61.3
27	12c	11.03	3.2	8.7	13.8	14.52	5.3	7.9
28	20a	31.11	29.5	28.5	47.7	37.9	27.4	54
29	20b	35.8	33.7	29.2	47.5	42.4	27.8	58.3
30	20c	32.31	7.5	8.6	46.4	44.7	6.8	10.9
31	16a	25.63	27.4	24.1	48.1	29.3	31.2	62.2
32	16b	26.32	33.6	27.6	41.1	26.8	29.4	46.2
33	16c	14.66	12.7	9	37.6	23.8	11.5	10.6
34	12d	23.08	28.5	23.8	43.3	37	27.7	43.4
35	12e	4.74	10.5	9.1	9.2	10.3	8	11.5
36	12f	8.29	6	×	6.7	5.8	5.4	6.6
37	8a	37.5	44.6	36.6	83.3	39.7	48.9	47.2
38	8b	105.2	91.8	98.6	309.7	211	63.3	139.3
39	8e	×	×	12.3	×	×	14.9	19.2
40	8d	17.91	13.3	11.9	31.3	28.7	15.9	24.7
41	2e	2.417	11.1	29.8	42.1	10.32	51.9	83.2
42	2f	9.9	10.9	12.4	5.2	8.9	8.3	11.4
43	2g	2	3.1	3.6	84.1	12.7	2.8	1.6
44	3c	5.43	8.7	13.3	5.7	4.9	13.6	4.4
45	3d	20.38	12.4	10.8	8.5	12.5	15.8	17.8
46	11f	11.23	39.8	95.5	47.3	52.4	102.7	17.5
47	11g	59.4	104.1	102.5	233.1	102.5	150.5	73.6
48	9d	24.02	25.7	24	31.1	26.8	9.3	22.6
49	9e	×	×	62.1	×	×	11.3	40
50	9f	46.4	22	18.6	38.6	45.3	22.5	47.4
51	9g	19.4	18.9	10.4	28.6	32.8	10.7	13.8

FOURTH FLOOR, LIGHTS ON

		4/3, 8:10pm Night Control	4/6 10AM Sunny	4/7 10AM Cloudy	4/7 12PM Cloudy	4/6 12PM Cloudy	4/6 4PM Cloudy
OBJECTID	Location						
1	6a	23.4	54.5	46.8	116.4	76.4	75

2	6b	45	41.8	58	141.9	107.3	11.4
3	6c	41.8	37.7	50	64.6	63.1	55.2
4	6d	52.3	54.2	47	72.4	59	51.7
5	4a	38.7	91.8	108	129	54	58.9
6	4b	40.6	89	105.6	137.7	115.8	121.6
7	4c	43.6	51	53.7	57.5	53.1	51.7
8	4d	45.9	59.2	58.5	74.9	65.2	67.5
9	3a	37.8	84.1	99.5	293.7	118.4	122.3
10	3b	44.1	88	102.8	116.4	91.6	88.6
11	Sa	39.7	46.2	58.5	78.2	63.8	60
12	Sb	32	67.5	75.5	148.7	73	71.7
13	Sc	18.3	60.8	69.5	245.6	104	99.9
14	3c	32.1	47.7	44.4	81.9	61.1	65.3
15	3d	36.1	40.7	69.3	51.6	46.6	45.3
16	5a	21.9	65.5	71.8	114.4	83.5	78.8
17	5b	21.6	51.2	55.7	117.5	53.3	51.1
18	5c	43.5	47.9	37.8	×	74.8	71.2
19	5d	41.3	52.8	56.7	65.6	57.9	60.4
20	1a	27.4	24.6	40.5	28.4	36.8	37
21	1b	25	39.1	45.1	48.2	43.8	46.2
22	2a	23.4	29.9	36.8	51.4	42.8	48.9
23	2b	31.1	37.2	45.5	54.5	43.3	47.8
24	12a	55.3	84.4	99	215.3	82.1	80.7
25	12b	27.4	28.8	47.5	56.9	39.7	41.3
26	10a	62.1	77.3	76	204.1	77.5	72.1
27	10b	43.6	46.8	57.3	67.8	36	37.3
28	8a	×	×	45.7	158.2	×	×
29	8b	30	28.7	46.8	72.1	46.1	51.6
30	8c	20.8	48.8	22.6	29.6	25.7	27.5
31	14a	×	×	×	×	×	×
32	14b	32.5	21.7	110	109	82.3	77
33	14c	30.3	80	43.5	69.4	52.1	60.2
34	14d	×	×	×	×	×	×
35	4e	34.9	40.2	73.7	119.6	75.8	76.1
36	4f	43.8	63.5	87.5	121.6	109.2	120.7
37	4g	46.6	84.5	67.5	62.4	55	54.6
38	4h	42.2	54	39.5	61.6	39.8	39.6
39	3e	×	×	×	×	×	×
40	3f	37.9	43.2	90.7	77.3	53.2	54.8
41	3g	46.8	73.5	53.3	64.4	59.6	40.6
42	3h	×	41.5	×	×	×	×

43	5e	50.7	105	85.5	191.7	93	95.2
44	5f	43	59.1	51.1	61	52.2	47.9
45	5g	41.5	38.5	46.3	52.9	32	30.3
46	5h	44	99.5	55.3	67.4	54	59.2
47	5i	47.7	53.5	55.8	61	56.3	55.9
48	1c	18.2	27.7	21.7	45.2	34.9	33
49	1d	20.5	25.2	31.5	50.6	34.1	34.5
50	2c	20.5	25.7	24.1	29.7	23.4	20.7
51	2d	24.5	33.5	27.6	52.6	39.7	35.4
52	10c	19.2	58.9	112	165.2	77.7	74.8
53	10d	67.7	100.8	132	243.7	88.6	90.2
54	12c	30.6	62.5	96.4	90.3	56.8	55.3
55	12d	30.8	77.5	112.8	201.8	79.5	77.1
56	8e	21.3	28	175.6	410	177.2	199.5
57	8d	23.5	65.5	105.2	559	105.8	117.9
58	8f	×	×	×	78.1	26.7	26.3

FOURTH FLOOR, LIGHTS OFF

		4/6 10 AM Sunny	4/7 10 AM Cloudy	4/7 12PM Cloudy	4/6 2 PM Cloudy	4/6 4 PM Cloudy
OBJECTID	Location					
1	6a	42.4	41.3	87.6	66	63.2
2	6b	25.05	88.3	118.9	70.7	73.4
3	6c	17.48	13.6	17.4	12.1	10.3
4	6d	9.63	13.6	21.4	10.2	11.2
5	4a	13.36	27.8	93.1	60.2	59
6	4b	57.3	117.5	103.1	71.7	72.1
7	4c	9.02	8.6	19.7	16.7	16.2
8	4d	22.5	19.5	23.7	18.4	15.2
9	3a	39.9	47.8	227.1	116.7	111.9
10	3b	27.63	48.1	91.6	65	62.5
11	Sa	27.93	23.6	42.9	30.1	33
12	Sb	24.81	53.4	104.2	49.6	54.2
13	Sc	30.82	180.1	193.9	55.2	58.7
14	3c	20.83	19.3	35.8	35.9	35.2
15	3d	9.55	7.2	19.2	18.4	23.4
16	5a	41.8	32.4	100.5	48.5	46.6
17	5b	23.82	198.5	51.5	33.2	31.8
18	5c	24.04	31.1	24.3	13.5	12.8

19	5d	13.84	21.7	24	18.8	16.1
20	1a	3.56	8.7	5.7	4.5	3
21	1b	15.18	18.4	21.4	12.3	12.7
22	2a	10.72	16.6	18.5	7.5	9.2
23	2b	9.27	15	14.7	13.9	14.1
24	12a	43.1	56.2	156.1	64.3	66.4
25	12b	33.03	28.1	27.7	12	10.9
26	10a	70.2	48.5	136.6	80.5	77.7
27	10b	21.24	40.8	36.1	23.3	21.5
28	8a	20.79	42.5	244.4	×	×
29	8b	16.38	41.4	42.8	10.7	13.2
30	8c	17.06	15.7	9.4	9.2	12.4
31	14a	×	×	×	×	56.1
32	14b	38.7	68.3	131.5	52	14
33	14c	15.47	29.3	27.9	15.5	43.6
34	14d	×	×	×	×	×
35	4e	40.5	36.2	97	45.3	43.6
36	4f	32.03	107.5	95.1	102.1	105.9
37	4g	6.07	8.9	14.1	9.8	8.8
38	4h	10.3	13.3	22.8	14.8	17
39	3e	×	×	×	×	×
40	3f	17.37	41.2	35.3	27	26.7
41	3g	4.89	7.7	15.5	16.6	15.3
42	3h	×	7.2	×	×	×
43	5e	24.09	16.3	162.2	76.5	80.1
44	5f	16.78	21.9	13.3	6.2	6.8
45	5g	5.76	3.7	5	3	2.9
46	5h	11.1	13.2	21.1	13.6	15
47	5i	7.37	10.3	10.3	6	6.7
48	1c	14.41	19.4	25.1	15.2	15.6
49	1d	12.31	18.7	10.9	8.3	10.4
50	2c	5.45	3.5	5.1	5.7	4.8
51	2d	18.89	27.5	26.4	20.2	21.8
52	10c	43	89.4	131.4	66.4	70.1
53	10d	84.2	126.3	166.2	77	77.6
54	12c	24.47	41.7	50.7	25.6	24.3
55	12d	53.9	78.7	130	44.9	43.4
56	8e	47.2	45.5	56.5	165.3	197.6
57	8d	20.79	8.6	58.3	75.7	90.2
58	8f	×	×	72.2	23.6	24